WE CLAIM:

1. An optical delay line comprising:

a plurality of differential delay lines; and

a plurality of phase actuated switchers connecting said plurality of differential delay lines.

2. The optical delay line of claim 1 wherein each of said plurality of differential delay lines comprises:

a long A optical fiber wherein said long A optical fiber is connected to at least one of said phase actuated switchers; and

a short B optical fiber wherein said short B optical fiber is connected to said at least one of said phase actuated switchers.

3. The optical delay line of claim 1 wherein at least one of said plurality of differential delay lines comprises:

a short B optical fiber that delays an input optical signal by t_B; and

a long A optical fiber wherein said long A optical fiber delays the input optical signal by t_A and $t_A - t_B$ is a time resolution τ of the optical delay line.

4. The optical delay line of claim 1 wherein at least one of said plurality of differential delay lines comprises:

a short B optical fiber that delays an input optical signal by t_B; and

a long A optical fiber wherein said long A optical fiber delays the input optical signal by t_A and $t_A - t_B$ is a multiple of a time resolution τ of the optical delay line.

5. The optical delay line of claim 1 wherein at least one of said plurality of differential delay lines comprises:

a short B optical fiber that delays an input optical signal by t_B; and

a long A optical fiber wherein said long A optical fiber delays the input optical signal by t_A and $t_A - t_B$ is a 2^k multiple of a time resolution τ of the optical delay line, for some integer value of $k \geq 0$.

6. The optical delay line of claim 1 wherein said plurality of phase actuated switchers connect said plurality of differential delay lines in pairs between an input and an output of the optical delay line.

7. The optical delay line of claim 1 wherein said plurality of phase actuated switchers connect said plurality of differential delay lines so that a delay between an input and an output of the optical delay line is the sum of the delays of the plurality of differential delay lines.

8. The optical delay line of claim 1 wherein:

a variable part of the optical delay line comprises said plurality of differential delay lines and said plurality of phase actuated switchers; and

said variable part allows digitally controlling a delay over the range from 0 to $(2^{N+1} - 1)\tau$ with a time resolution of τ.

9. The optical delay line of claim 1 wherein said plurality of phase actuated switchers simultaneously adjusts a phase of an input signal to modulate said phase of said input signal.

10. An optical delay line comprising:

a plurality of optical fiber differential delay lines; and

a plurality of phase actuated switchers connecting said plurality of optical fiber differential delay lines.

11. The optical delay line of claim 10 wherein each of said plurality of optical fiber differential delay lines comprises:

a long A optical fiber wherein said long A optical fiber is connected to a first one and a second one of said plurality of phase actuated switchers; and

a short B optical fiber wherein said short B optical fiber is connected to said first one and said second one of said plurality of phase actuated switchers.

12. The optical delay line of claim 10 wherein at least one of said phase actuated switchers includes:

a fiber coupler connected to at least one of said plurality of optical fiber differential delay lines; and

a light phase adjustment device connected to said fiber coupler.

13. The optical delay line of claim 10 wherein at least one of said phase actuated switchers includes:

a fiber coupler connected to at least one of said plurality of optical fiber differential delay lines; and

a spatial light modulator that reflects an input signal from said fiber coupler.

14. The optical delay line of claim 10 wherein at least one of said phase actuated switchers includes:

a fiber coupler connected to at least one of said plurality of optical fiber differential delay lines;

at least one switch fiber connected to said fiber coupler; and

a piezoelectric-stretcher attached to said switch fiber.

15. The optical delay line of claim 10 wherein at least one of said

plurality of optical fiber differential delay lines comprises:

a short B optical fiber having a length L^k_B;

a long A optical fiber having a length L^k_A wherein said differential delay line delays an input optical signal by an amount of time proportional to $(L^k_A - L^k_B)$.

16. The optical delay line of claim 10 wherein at least one of said plurality of optical fiber differential delay lines comprises:

a short B optical fiber having a length L^k_B;

a long A optical fiber having a length L^k_A wherein:

said differential delay line delays an input optical signal by an amount of time $(t_A - t_B)$ proportional to $(L^k_A - L^k_B)$; and

$(t_A - t_B) = 2^k \tau$, for some integer value of $k \geq 0$, where τ is a time resolution of the optical delay line.

17. The optical delay line of claim 16 wherein:

said plurality of phase actuated switchers connect said plurality of differential delay lines in pairs between an input and an output of the optical delay line so that a differential delay Δt between an input and an output of the optical delay line is the sum of the differential delays of each of the plurality of differential delay lines; and

$\Delta t = \tau \sum_{j=1}^{M} 2^{k_j}$, where $\{k_1, \ldots, k_M\}$ is a set differential delay lines with an A optical fiber selected.

18. An optical communication system comprising:

a plurality of optical fiber differential delay lines; and

a plurality of phase actuated switchers connecting said plurality of optical fiber differential delay lines in pairs wherein:

at least one of said plurality of optical fiber differential delay lines comprises:

a long A optical fiber wherein said long A optical fiber is connected to a first one and a second one of said plurality of phase actuated switchers; and

a short B optical fiber wherein said short B optical fiber is connected to said first one and said second one of said plurality of phase actuated switchers.

19. The system of claim 18 wherein at least one of said phase actuated switchers includes:

a fiber coupler connected to at least one of said plurality of optical fiber differential delay lines;

at least one switch fiber connected to said fiber coupler; and

an electronically controlled electro-optical modulator that adjusts the phase of an input signal in said switch fiber.

20. The system of claim 18 wherein at least one of said phase actuated switchers includes:

a fiber coupler connected to at least one of said plurality of optical fiber differential delay lines;

at least one switch fiber connected to said fiber coupler;

a collimator at an end of said switch fiber; and

a mirror of an electronically controlled spatial light modulator that reflects an input signal from said collimator back into said collimator.

21. The system of claim 18 wherein at least one of said phase actuated switchers includes:

a fiber coupler connected to at least one of said plurality of optical fiber differential delay lines;

at least one switch fiber connected to said fiber coupler; and

an electronically controlled bi-refringent crystal connected to said switch fiber.

22. The system of claim 18 wherein at least one of said phase actuated switchers includes:

a fiber coupler connected to at least one of said plurality of optical fiber differential delay lines;

at least one switch fiber connected to said fiber coupler and terminated with a mirror; and

an electronically controlled piezoelectric-stretcher attached to said switch fiber between said fiber coupler and said mirror.

23. The system of claim 18 wherein said plurality of optical fiber differential delay lines includes N+1 differential delay lines numbered by k from 0 to N and for each specific value of k, the k-th differential delay line comprises:

a k-th short B optical fiber having a length L^k_B;

a k-th long A optical fiber having a length L^k_A wherein:

said k-th differential delay line delays an input optical signal by an amount of time $(t^k_A - t^k_B)$ proportional to $(L^k_A - L^k_B)$;

$(t^k_A - t^k_B) = 2^k \tau$, where τ is a time resolution of the optical delay line;

said N+1 differential delay lines and said plurality of phase actuated switchers allows digitally controlling a differential delay Δt over the range from 0 to $(2^{N+1} - 1)\tau$ with a time resolution of τ; and

$\Delta t = \tau \sum_{i=1}^{M} 2^{k_i}$, where $\{k_1, ..., k_M\}$ is a set differential delay lines with an A optical fiber selected.

24. An optical system comprising:

a plurality of optical fiber differential delay lines; and

a plurality of phase actuated switchers connecting said plurality of optical fiber differential delay lines in pairs wherein:

said plurality of optical fiber differential delay lines includes N+1 differential delay lines numbered by k from 0 to N, said plurality of phase actuated switchers includes N+2 phase actuated switchers numbered by k from 0 to N+1, and for each specific value of k, the k-th differential delay line comprises:

a k-th short B optical fiber having a length L^k_B and connected between a k-th phase actuated switcher and a (k+1)-th phase actuated switcher of said plurality of phase actuated switchers;

a k-th long A optical fiber having a length L^k_A and connected between said k-th phase actuated switcher and said (k+1)-th phase actuated switcher of said plurality of phase actuated switchers and wherein:

said k-th differential delay line delays an input optical signal by an amount of time $(t^k_A - t^k_B)$ proportional to $(L^k_A - L^k_B)$;

$(t^k_A - t^k_B) = 2^k \tau$, where τ is a time resolution of the optical delay line;

said N+1 differential delay lines and said plurality of phase actuated switchers allows digitally controlling a differential delay Δt over the range from 0 to $(2^{N+1} - 1)\tau$ with a time resolution of τ; and

$\Delta t = \tau \sum_{i=1}^{M} 2^{k_i}$, where $\{k_1, ..., k_M\}$ is a set of said N+1 differential delay lines with an A optical fiber selected by one of said plurality of phase

actuated switchers.

25. A phased fiber array system comprising:

a multi-channel programmable fiber delay line/phase modulator including, for at least one channel of a plurality of channels:

a digitally controllable optical delay line comprising:

a plurality of differential delay lines; and

a plurality of phase actuated switchers connecting said plurality of differential delay lines in pairs; and wherein:

said plurality of phase actuated switchers allows digitally controlling a delay on said channel over the range from 0 to $(2^{N+1} - 1)\tau$ with a time resolution of τ; and

said plurality of phase actuated switchers simultaneously adjusts a phase of an input signal to modulate said phase of said input signal on said channel;

an amplifier module connected to said multi-channel programmable fiber delay line/phase modulator;

a photo detector that receives amplified signals from said amplifier module; and

a feedback module that receives electronic signals from said photo detector and provides electronic control signals to said multi-channel programmable fiber delay line/phase modulator, wherein said electronic control signals provide synchronization and phase adjustment of said input signal on said plurality of channels.

26. The phased fiber array system of claim 25, further comprising:

a spatial light modulator wherein said electronic control signals switch on a proper combination of said differential delay lines of said at least one digitally controllable optical delay line by adjusting at least one mirror of

said spatial light modulator to individually adjust the delay of at least one channel of said plurality of channels.

27. The phased fiber array system of claim 25, further comprising:

a collimator array that receives amplified signals from said amplifier module and provides focused light beams to said photo detector.

28. The phased fiber array system of claim 25, further comprising:

a seed laser that feeds input signals to said multi-channel programmable fiber delay line/phase modulator.

29. An optical phase modulator comprising:

a plurality of optical fiber differential delay lines; and

a plurality of phase actuated switchers connecting said plurality of optical fiber differential delay lines, wherein:

each of said phase actuated switchers includes:

a fiber coupler connected to at least one of said plurality of optical fiber differential delay lines; and

a light phase adjustment device connected to said fiber coupler; and

each of said light phase adjustment devices is simultaneously controllable to adjust a phase of an input signal and modulate said phase of said input signal.

30. The optical phase modulator of claim 29, wherein:

said plurality of phase actuated switchers connects said plurality of optical fiber differential delay lines in pairs and wherein:

at least one of said plurality of optical fiber differential delay lines comprises:

a long A optical fiber wherein said long A optical fiber is connected

to a first one and a second one of said plurality of phase actuated switchers; and

a short B optical fiber wherein said short B optical fiber is connected to said first one and said second one of said plurality of phase actuated switchers.

31. The optical phase modulator of claim 29, wherein:

said plurality of phase actuated switchers includes a plurality of light phase adjustment devices that are simultaneously controllable to adjust a phase of an input signal and modulate said phase of said input signal.

32. An optical commutator comprising:

a plurality of optical fiber differential delay lines; and

a plurality of phase actuated switchers connecting said plurality of optical fiber differential delay lines, wherein:

at least one of said plurality of phase actuated switchers is connected to a channel; and

at least one of said plurality of phase actuated switchers is connected to a fiber delay line.

33. The optical commutator of claim 32 wherein:

each of said plurality of phase actuated switchers is connected to a distinct channel of a plurality of channels;

at least one of said plurality of phase actuated switchers is connected to a fiber delay line; and

any pre-determined channel of said plurality of channels is connected to said fiber delay line via operation of said plurality of phase actuated switchers.

34. The optical commutator of claim 32 wherein:

each of said plurality of phase actuated switchers is connected to a distinct channel of a plurality of channels;

at least one of said plurality of phase actuated switchers is connected to a fiber delay line;

said fiber delay line is connected to a first phase actuated switcher of said plurality of phase actuated switchers; and

any two pre-determined channels of said plurality of channels are connected to each other via operation of said plurality of phase actuated switchers.

35. The optical commutator of claim 32 wherein:

said plurality of phase actuated switchers connects said plurality of optical fiber differential delay lines in pairs and wherein:

at least one of said plurality of optical fiber differential delay lines comprises:

a long A optical fiber wherein said long A optical fiber is connected to a first one and a second one of said plurality of phase actuated switchers; and

a short B optical fiber wherein said short B optical fiber is connected to said first one and said second one of said plurality of phase actuated switchers.

36. The optical commutator of claim 32 wherein:

each of said plurality of phase actuated switchers is connected to a distinct channel of a plurality of channels;

one of said plurality of phase actuated switchers is connected to a fiber delay line; and

said plurality of phase actuated switchers are operated to connect any pre-determined channel of said plurality of channels to an output via said

fiber delay line.

37. The optical commutator of claim 32 wherein:

each of said plurality of phase actuated switchers is connected to a distinct channel of a plurality of channels;

one of said plurality of phase actuated switchers is connected to a fiber delay line;

said fiber delay line is connected to a first phase actuated switcher of said plurality of phase actuated switchers; and

said plurality of phase actuated switchers are operated to connect any two pre-determined channels of said plurality of channels to each other via said fiber delay line.

38 A method for providing a differential delay in an optical signal comprising a step of:

switching an input signal to have any delay in a pre-determined dynamic range with time resolution τ.

39. The method of claim 38 wherein said switching step further includes:

switching the input signal either into a long A optical fiber of a differential delay line or else into a short B optical fiber of said differential delay line.

40. The method of claim 38 wherein said switching step further includes:

switching the input signal among a plurality of differential delay lines so that the input signal is delayed by a sum of delays and said sum of delays includes a combination of long A optical fibers and short B optical fibers

of said plurality of differential delay lines.

41. The method of claim 38 wherein said switching step further includes:

providing a first differential delay line with a minimum time delay τ;

providing at least one second differential delay line with a time delay that is a multiple of time delay τ; and

providing phase actuated switchers capable of switching the input signal among all possible combinations of long A optical fibers and short B optical fibers of said first and second differential delay lines so that a differential delay of the input signal may sum to any multiple of τ within a predetermined total range.

42. The method of claim 38 wherein said switching step further includes:

switching the input signal over a variable part of a delay line, wherein said variable part comprises a plurality of differential delay lines allowing digitally controlling a delay over the range from 0 to $(2^{N+1} - 1)\tau$ with a time resolution of τ.

43. The method of claim 38 wherein said switching step further includes:

adjusting the phase of the input signal by simultaneously controlling multiple phase actuated switchers to provide phase modulation of the input signal.